

## Criminal Liability for Environmental Damage Caused by Artificial Intelligence Systems

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### Abstract

The world is witnessing an unprecedented digital transformation driven by the rapid development of artificial intelligence systems. While these technologies have revolutionized many aspects of life, they have also created serious environmental risks, ranging from digital pollution caused by their infrastructure to direct environmental harm resulting from autonomous algorithmic decisions. This study critically examines the issue of criminal liability for environmental damage caused by AI systems. It analyzes the specific nature of such damage and the main challenges facing the application of traditional criminal law, particularly those related to the mental element, causation, and attribution. The paper also reviews contemporary legal approaches, including the extension of existing rules and the development of new liability frameworks, while assessing their ability to balance environmental protection and technological innovation. It further highlights recent legislative developments, especially the 2024 EU Artificial Intelligence Act and the 2024 Environmental Crime Directive.

**Keywords:**Criminal liability; artificial intelligence; environmental damage; strict liability; digital ecocide; European Artificial Intelligence Act; Environmental Crime Directive.

## **1. INTRODUCTION**

In recent decades, artificial intelligence has become a central driver of global technological transformation, as the pace of developing and deploying these systems has accelerated across various economic, industrial, and service sectors. Alongside the substantial benefits these technologies offer, such as improving production efficiency and reducing resource consumption, growing concerns have emerged regarding their negative environmental impacts. These concerns arise both from the massive carbon footprint associated with training and operating large-scale models and from the direct environmental harm that may result from autonomous algorithmic decision-making in fields such as autonomous transport, automated manufacturing, and natural resource management .

Professor Youssef Mazhar Ahmed, in his study on the impact of artificial intelligence on the environment from the perspective of Iraqi criminal law, notes that artificial intelligence has a dual effect on the environment in which human beings live. On the one hand, it plays a positive role in environmental protection by reducing the risks associated with machines and technology; on the other hand, it has negative effects on human beings through radiation emissions, gases, and the machinery used by these technologically advanced systems at both the domestic and international levels

The forms of environmental damage that may arise from artificial intelligence systems are diverse. In addition to the direct effects resulting from algorithmic decisions, they include indirect harms such as digital pollution generated by cloud computing infrastructure and data centers, as well as fraudulent practices in which AI technologies are used to manipulate environmental data or mislead regulatory authorities. This phenomenon has come to be known as “algorithmic greenwashing” .

In this context, the concept of “cyber ecocide” has emerged as a new form of environmental crime committed or concealed through digital systems, including data manipulation in emissions reports, algorithmic greenwashing, and AI-assisted environmental fraud .

These developments raise a fundamental legal question: to what extent are the traditional rules of criminal liability—built upon the concepts of human will, criminal intent, and direct causation—capable of being applied to environmental harm that may result from autonomous algorithmic decisions characterized by complexity and unpredictability? Can the principle of criminal legality be reconciled with the need to criminalize new forms of conduct unfamiliar to the traditional legislator? These questions lie at the heart of the present study.

## **2. Patterns of Environmental Damage Caused by Artificial Intelligence Systems**

Analyzing criminal liability for environmental damage caused by artificial intelligence requires a precise understanding of the patterns and characteristics of such damage, as the nature of legal attribution varies depending on the type of damage and its source. These forms of damage may be classified as follows:

### **2.1 Direct Environmental Damage**

Direct environmental damage arises when an artificial intelligence system makes an autonomous decision or executes an action that causes tangible environmental harm. The most notable examples in this context include:

#### **2.1.1 Autonomous Vehicle Accidents**

Autonomous driving systems may cause accidents that result in the spillage of hazardous substances or fuel leaks that contaminate soil and water. Such harm may occur as a result of an error in the sensing system, data processing, or algorithmic decision-making (Fernando & Firdaus , 2025, pp. 211-219)

#### **2.1.2 Industrial Control Systems**

Errors in AI systems used in factories and industrial facilities may lead to the release of toxic emissions, the leakage of dangerous chemicals, or the unsafe operation of equipment, thereby causing widespread environmental damage (Hallevy , 2019)

#### **2.1.3 Natural Resource Management Systems**

Algorithms used in the management of water, energy, or forests may lead to environmentally unsound decisions, such as the over-extraction of

groundwater or deforestation beyond sustainable limits, due to inaccuracies in predictive models or bias in the data used for training.

## **2.2 Indirect Environmental Damage (The Environmental Footprint of Artificial Intelligence)**

This category of damage consists of the environmental effects resulting from the development and operation of artificial intelligence systems themselves, regardless of their practical functions:

### **2.2.1 Energy Consumption**

Training large AI models requires enormous amounts of electrical energy, resulting in greenhouse gas emissions, particularly when the energy sources are non-renewable. Some studies estimate that training a single large language model can generate carbon emissions equivalent to those produced by five cars over their entire lifetime (Pagallo, 2025)

### **2.2.2 Water Consumption**

The massive data centers that operate AI systems depend on large quantities of water for cooling purposes, thereby placing pressure on freshwater resources in the regions where these centers are located. Studies have indicated that the European Union Artificial Intelligence Act lacks specific reporting requirements concerning water consumption, unlike the provisions available for energy consumption

### **2.2.3 Electronic Waste**

The rapid development of computing hardware used in artificial intelligence, such as specialized processors and graphics processing units, shortens the lifespan of these devices, thereby increasing the volume of electronic waste containing toxic substances that pose risks to the environment and public health.

## **2.3 Fraudulent Environmental Damage (Algorithmic Greenwashing)**

Algorithmic greenwashing represents a new and complex form of environmental harm, whereby artificial intelligence systems are used to conceal, distort, or falsify environmental data, or to mislead consumers and regulatory authorities regarding the environmental impact of products or

companies.

In this context, Singh and Singh, in their comparative study on algorithmic criminal liability in greenwashing, observe that current laws reflect an anthropocentric bias by making liability dependent on proving human intent, which renders them ill-equipped to address algorithmic deception (Singh & Manjit , 2024, pp. 51-68). The study further reveals a critical gap in doctrinal adaptation, as prevailing fraud laws remain outdated in relation to AI-generated misrepresentation (Gabriel, 2024)

The seriousness of this form of damage lies in its capacity to undermine environmental protection efforts as a whole. When companies succeed in using artificial intelligence to present a misleading environmental image, this creates an unfair market that discourages companies genuinely committed to environmental standards, deprives consumers of the accurate information they need to make informed decisions, and weakens the effectiveness of regulatory oversight

### **3. Dilemmas of Traditional Criminal Liability in Addressing Environmental Damage Caused by Artificial Intelligence**

#### **3.1 First Subtitle**

Traditional rules of criminal liability face structural challenges when applied to environmental damage caused by artificial intelligence systems. These dilemmas may be grouped under three main headings:

#### **3.1 The Problem of the Mental Element (Criminal Intent and Negligence)**

The mental element is a cornerstone of traditional criminal liability, since no crime exists without the presence of criminal intent—whether general or specific—or unintentional fault that warrants criminalization. However, artificial intelligence systems, particularly those based on deep learning and neural network technologies, operate in ways that cannot easily be reduced to the conventional categories of human will and intent .

A recent study on the rules of criminal liability and artificial intelligence devices concluded that “the mental element of the traditional offense is incompatible with the nature of autonomous AI devices that possess the capacity for self-learning and decision-making” The study also showed that it is difficult to allocate liability among the various parties

involved—developers, manufacturers, owners, and users—especially when the error is unclear or highly complex .

This problem becomes even more acute in cases of unintentional environmental harm, where proving negligence, recklessness, or lack of due care becomes far more complicated in light of the “black box” nature of intelligent systems, which makes it difficult even for developers themselves to understand how the system arrived at a particular decision. How, then, can it be established that a developer was negligent in designing the system if the developer could not reasonably foresee the system’s behavior in all circumstances?

### **3.2 The Problem of Causation and Attribution**

Traditional rules of criminal liability require the establishment of a direct causal link between the conduct of the offender and the criminal result. Yet, in the context of environmental damage caused by artificial intelligence, the chain of causation is often complex and fragmented.

For example, if an autonomous AI system causes the leakage of toxic substances from a factory, should causation be attributed to the programmer who designed the core algorithms? To the manufacturing company that supplied the training data? To the manager who approved the use of the system? Or to the system itself? All of these questions remain without clear answers under current legal frameworks .

Fernando and Arifin point to the existence of critical legal gaps in attributing criminal liability for digital environmental crimes, particularly with respect to corporate actors and automated technologies. These gaps become even more complex when several AI systems are involved in the decision-making chain, or when the system interacts with environmental variables that were not taken into account during the design phase.

### **3.3 The Problem of the Legal Personality of Artificial Intelligence**

Contemporary legal scholarship has raised considerable debate over the possibility of recognizing artificial intelligence systems as having legal personality—whether full or limited—in a way that would allow them to be held directly criminally liable, in a manner similar to legal entities such as

corporations.

In this regard, a previous study recommended that legislators adopt a special legal classification for artificial intelligence devices that takes into account their dual nature, lying between tangible physical existence and a non-human software dimension, so that they are neither treated as mere inanimate objects nor granted full legal personality. Instead, the study proposed the creation of a special legal status that reflects their technical characteristics and defines the scope of liability arising from their use .

Even so, this path remains fraught with challenges. Most notably, the notion of legal personality for machines is difficult to reconcile with the principles of traditional criminal law, which ground punishment on moral foundations requiring will and awareness. Moreover, recognizing legal personality for artificial intelligence may create loopholes for impunity if systems are designed in such a way that it becomes impossible to trace the real responsibility behind them .

#### **4. Scholarly Proposals for Developing Frameworks of Criminal Liability**

In response to the structural deficiencies of traditional rules, contemporary legal scholarship has developed several proposals for improving the frameworks of criminal liability for environmental damage caused by artificial intelligence. These proposals may be classified under three main headings:

##### **4.1 Expanding the Scope of Strict Liability**

Strict liability consists in holding a person criminally responsible for the harmful consequences of a given act without the need to prove intent or negligence, within the context of specific offenses characterized either by exceptional gravity or by the difficulty of proving the mental element.

Recent legal scholarship shows a growing tendency toward adopting the model of strict liability in addressing harm caused by artificial intelligence (European , 2025).

.. In a study conducted by the European Parliament in July 2025, a framework of strict liability was proposed for high-risk systems, to be borne by the providers and/or operators of such systems. Under this framework, they may not evade liability by arguing that they acted with due diligence or

that the harm resulted from the independent activity of their AI system, except in cases of force majeure or reckless conduct on the part of the injured party

These proposals are reinforced by the findings of Singh and Singh, whose study confirmed the usefulness of strict liability models and governance frameworks equivalent to algorithmic accountability .

In the environmental context, strict liability may be applied to environmental damage caused by artificial intelligence systems in high-risk activities, such as the management of nuclear facilities, chemical plants, or large-scale autonomous transport systems. As the parties best positioned to control and distribute risk, the developer and the operator would bear criminal liability for any environmental harm caused by the system, regardless of whether the mental element is established.

#### **4.2 The Introduction of Endangerment Offences**

The second approach lies in the creation of endangerment offences, under which the offense is complete without the occurrence of actual harm; it is sufficient that the conduct in question creates a serious risk to the environment.

This legal model appears particularly promising in the context of environmental damage caused by artificial intelligence for the following reasons:

First, it overcomes the problem of causation. Since the offense is established by the mere creation of the risk, there is no need to prove a causal relationship between the system's conduct and actual environmental damage, thereby avoiding one of the most serious difficulties faced by traditional law.

Second, it strengthens prevention. Endangerment offences focus on the preventive dimension, thereby encouraging developers and operators to adopt the highest standards of safety and environmental oversight.

Third, it is proportionate to the nature of the risks involved. Environmental damage arising from artificial intelligence is often marked by scientific uncertainty, since it may be impossible to foresee all the potential effects of

a system before it is deployed on a large scale. In such circumstances, criminalizing the creation of unjustified risks appears more equitable than waiting until catastrophe occurs.

In this context, legal scholarship offers two principal approaches to criminal liability in the age of artificial intelligence: the use of the doctrine of “permissible risk” and the introduction of endangerment offences. Whereas the doctrine of permissible risk narrows the scope of criminalization in order to encourage innovation, provided that the developer has complied with prevailing industry standards, endangerment offences raise the level of environmental protection by criminalizing conduct that creates unacceptable risks, even if no actual harm results.

#### **4.3 Hybrid Frameworks of Liability**

The third approach concerns the development of hybrid liability frameworks, combining elements of the previous models while drawing on tools of algorithmic risk assessment and concepts of limited legal personality.

Singh and Singh advocate the adoption of a hybrid liability framework that integrates algorithmic risk assessment with legal personality structures, so as to ensure that the opacity of algorithms does not prevent the enforcement of liability. This means that the legal system may recognize artificial intelligence as a “limited legal person” for accountability purposes only, while preserving the possibility of recourse against the human actors behind it—developers, owners, and operators—in cases of gross negligence or criminal intent.

This hybrid model appears more flexible and better able to adapt to the diversity of environmental harm scenarios, as it allows liability to be distributed in a manner proportionate to the degree of control and the cognitive capacity of each party.

### **5. Regional and International Legislative Developments**

In recent years, the international and regional legislative landscape has witnessed important developments in the regulation of artificial intelligence and environmental crime, although these developments still fall short of providing comprehensive answers to the problem of criminal liability.

#### **5.1 The 2024 European Union Artificial Intelligence Act**

The European Union Artificial Intelligence Act (Regulation (EU) 2024/1689) is regarded as the first comprehensive legislation in the world to regulate artificial intelligence systems on a risk-based basis. The Act entered into force in August 2024 and aims to provide a uniform set of rules governing the placing of AI systems on the European market and their use

The Act states that it seeks to ensure “the protection of the environment, while promoting innovation,” and it imposes a number of requirements relating to energy consumption and transparency. (European Union., 2024)

Its provisions also include, in Article 9, measures for high-risk management; in Article 27, an assessment of the impact on fundamental rights; and in Article 95, voluntary codes of conduct .

However, Pagallo’s analysis indicates that the provisions of Articles 9, 27, and 95 are among the least environmentally ambitious in the legislation as a whole. Other studies have likewise concluded that the environmental provisions of the Artificial Intelligence Act are limited in scope and rely primarily on voluntary codes of conduct and weak technical documentation requirements concerning environmental impacts .

More importantly for the purposes of this study, the Artificial Intelligence Act does not cover liability rules for damage caused by the outputs of AI systems, as these issues were intended to be addressed in the proposed AI Liability Directive, which was later withdrawn and reformulated .

## **5.2 The 2024 European Union Environmental Crime Directive**

In a parallel development, the European Union adopted Directive (EU) 2024/1203 on environmental crime, which significantly expands the obligations of Member States and introduces “qualified offences” for conduct causing long-term or irreversible environmental damage .

The Directive requires the imposition of criminal liability on both natural persons and legal entities, with penalties reaching up to ten years’ imprisonment . Although the Directive does not use the term “ecocide,” its effect clearly moves in that direction (European Union., 2024)

From the perspective of its relationship to artificial intelligence, it may be

said that the Directive provides a general criminal framework capable of encompassing environmental damage caused by intelligent systems, particularly in cases where such harm is “long-term” or “irreversible.” Nevertheless, the Directive remains silent regarding the specific nature of algorithmic harm, thereby leaving Member States to confront the problems of attribution and causation discussed earlier.

### **5.3 International Initiatives to Criminalize Ecocide**

At the international level, Pacific Island States have proposed adding ecocide to the Rome Statute of the International Criminal Court [reference:28]. Although the International Criminal Court has not yet incorporated this crime into its Statute, these initiatives reflect a growing recognition of environmental harm as a matter of international criminal justice (Fernando & Firdaus , 2025, p. 217)

In this context, the concept of “digital ecocide” appears as a natural extension of these initiatives, insofar as digital systems, especially artificial intelligence, may be used to facilitate or conceal acts that cause large-scale environmental damage. Analyses also point to the existence of critical legal gaps in attributing criminal liability for digital environmental crimes, particularly with regard to corporate actors and automated technologies (Fernando & Firdaus , 2025, p. 219)

### **5.4 National and Arab Legislation**

At the national level, legislation varies considerably in its treatment of criminal liability for environmental damage caused by artificial intelligence. While some states, such as Germany and France, have adopted a proactive approach in developing their laws, the legislation of other states, including most Arab countries, remains far from keeping pace with these challenges.

In the Iraqi context, existing laws—such as the Iraqi Penal Code No. 111 of 1969, as amended, and the in-force Environmental Protection and Improvement Law No. 27 of 2009—have been examined in terms of the positive and negative effects of artificial intelligence on the environment and the circumstances in which criminal liability may arise (Al-Dhahani, 2025)

. In the Palestinian context, however, Palestinian law does not recognize artificial intelligence as possessing independent legal personality, and therefore it cannot be held liable in and of itself (Al-Falasi, 2021)

## **6. CONCLUSION**

### **Findings**

**First:** Environmental damage caused by artificial intelligence systems takes multiple forms, including direct damage (such as accidents involving autonomous vehicles and industrial control systems), indirect damage (the environmental footprint of artificial intelligence, represented by energy and water consumption and electronic waste), and fraudulent damage (algorithmic greenwashing). Each of these forms gives rise to specific legal challenges in terms of attribution and proof.

**Second:** Traditional rules of criminal liability reveal structural deficiencies in dealing with environmental damage caused by artificial intelligence. The most significant manifestations of this deficiency lie in the difficulty of reconciling the traditional mental element with the nature of autonomous intelligent systems, the challenge of establishing a clear causal link within complex algorithmic decision chains, and the ongoing debate over whether artificial intelligence should be granted legal personality as a means of **enabling** direct criminal accountability.

**Third:** Contemporary legal scholarship offers several proposals for developing frameworks of criminal liability. The most notable of these include expanding the scope of strict liability to cover environmental damage caused by high-risk systems, introducing endangerment offences that emphasize the preventive dimension, and adopting hybrid liability frameworks that combine algorithmic risk assessment with concepts of limited legal personality. Some studies have also concluded that strict liability models and governance frameworks equivalent to algorithmic accountability represent a promising solution.

**Fourth:** Regional and international legislative developments, particularly the 2024 European Union Artificial Intelligence Act and the 2024

Environmental Crime Directive, demonstrate a growing recognition of the need to regulate artificial intelligence and to protect the environment through criminal law. Nevertheless, these instruments still suffer from fundamental gaps with respect to direct criminal liability for environmental damage caused by intelligent systems. The Artificial Intelligence Act does not address liability rules, while the Environmental Crime Directive contains no specific provisions concerning algorithmic harm.

### **Recommendations**

**First:** We recommend that national and Arab legislators amend penal laws and environmental protection laws to include specific provisions on criminal liability for environmental damage caused by artificial intelligence systems, with particular emphasis on the following:

- Incorporating strict liability as a basis for accountability in environmentally high-risk activities involving artificial intelligence;
- Introducing endangerment offences relating to the operation of intelligent systems; and
- Establishing a special legal classification for artificial intelligence systems that takes into account their dual nature without granting them full legal personality.

**Second:** We encourage academic and research communities to continue developing theoretical models of criminal liability in the age of artificial intelligence, with particular focus on creating practical mechanisms for overcoming the “black box” problem in algorithms and on devising fair methods for distributing liability among the multiple parties involved in the development and operation of these systems.

**Third:** We recommend that regional legislative bodies, such as the League of Arab States and the African Union, develop unified regional legal frameworks to address the cross-border challenges posed by environmental damage caused by artificial intelligence, following the example of the European Union while taking into account the legal and economic particularities of Arab states.

**Fourth:** We call for stronger cooperation among legal scholars, artificial intelligence experts, and environmental specialists in order to formulate binding technical standards aimed at reducing the environmental risks of

intelligent systems. Such standards could serve as a basis for criminal accountability when violated.

**Fifth:** We propose that the subject of legal liability for artificial intelligence, especially its environmental and criminal dimensions, be incorporated into the curricula of law schools and postgraduate studies in order to prepare a new generation of legal professionals capable of addressing these emerging challenges.

**Sixth:** We recommend that Arab states draw on the 2024 European Environmental Crime Directive as a guiding model for developing their criminal environmental legislation, while adding specific provisions on algorithmic harm and digital greenwashing in a manner consistent with the particular characteristics of Arab legal systems.

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